ROYAL GARDENS, KEW.

BULLETIN

OF

MISCELLANEOUS INFORMATION.

No. 37.] JANUARY. [1890.

CXXVII.—THE WEATHER PLANT.

Abrus precatorius, Linn.

During the year 1888 numerous notices appeared in London newspapers giving accounts from Vienna of a plant the movements of which predicted the changes of weather. The following, which is taken from the "St. James's Gazette" for August 30th, will serve as an example :—

"THE 'WEATHER PLANT.'

"The 'weather plant' continues to excite considerable interest at "Vienna. Men of science, who on its first discovery were unwilling "to express an opinion on its prognosticating virtues, now agree, after "extensive experiments, that the shrub is in truth prophetic. Thirty-"two thousand trials made during the last three years tend to prove its "infallibility. The plant itself is a legume, commonly called the "'Paternoster-pea,' but known in botany as the *Abrus peregrinus*. It is "a native of Corsica and Tunis. Its leaf and twig strongly resemble "those of the acacia. The more delicate leaves of its upper branches "foretell the state of the weather forty-eight hours in advance, while "its lower and hardier leaves indicate all atmospheric changes three

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" days beforehand. The indications consist in a change in the position " of the leaves and in the rise and fall of the twigs and branchlets."

In the "Times" for November 5th following, a statement claiming even more remarkable properties for the plant was published from the Vienna correspondent of that Journal. It is quoted verbatim :—

" The British Consul-General in Vienna has been instructed by the " Foreign Office to request Professor Nowack to furnish him with in- " formation about his famous weather plant. The Committee of the " Jubilee Exhibition which has just closed has promised Professor " Nowack a certificate, to the effect that the weather forecasts made by " his plants were correct in 96 cases out of 100. I have been requested " by Professor Nowack to state that owing to the great number of " letters he has received from England he has made arrangements with " Mr. C. W. Radeke, of Clapham Common, to exhibit the plant in " England, and to answer all inquiries about it. Further, Herr Nowack " wishes it to be known that his plants are now giving indications of " shocks of earthquake, which may be expected to occur during the " next week within 100 German miles south of Vienna. On several " occasions these predictions as to earthquakes have been useful in " enabling mine owners to take precautions for preventing loss of life " in colliery explosions."

It is not known whether any report upon the subject from the British Consul-General at Vienna reached the Foreign Office. At any rate no copy has been received at this establishment, though the Foreign Office usually transmits to it any information bearing upon botanical subjects.

At a meeting of the Royal Botanic Society of London on November 10th the secretary, Mr. William Sowerby, F.L.S., exhibited " plants of the " so-called 'Vienna Weather Plant,' *Abrus precatorius*, from the Society's " garden." He stated that "the behaviour of the several specimens " . . . . varied at one and the same time according to the special " conditions under which they were growing."

It may be noticed that Mr. Sowerby identified the weather plant with *Abrus precatorius*. In point of fact no such name as *Abrus peregrinus* is known to botanists.

Mr. Sowerby's remarks were communicated to the " Times," and produced the following reply :—

To the Editor of the "Times."

Sir,

As the London correspondent of Professor Nowack, of Vienna, I beg leave to say a few words in reply to the statement in the "Times" of yesterday, with reference to the recent meeting of the Royal Botanic Society, and concerning the weather plant.

From the explanations given by the Secretary of the Society it is obvious that the Royal Botanic Society is labouring under an entire misapprehension as to what really forms the gist and nature of Professor Nowack's discovery, and also that the weather plants in the Society's gardens are not cultivated in the manner needful for his purpose. Mr. Nowack does not in the least dispute the Secretary's allegation, " that the behaviour of the weather plant in the Society's " (or any other) gardens varied at one and the same time, according to " the special conditions under which they are growing "; quite the contrary, he is fully aware of it, and admits that weather plants grown under ordinary conditions are utterly useless for forecasting the weather. But Professor Nowack contends, on the other hand, (1), that

the weather plant is an electro-magnetic plant; (2) that if it is placed, corresponding with a magnetic compass with its north branches towards north, in an apparatus of his own special, but, after all, very simple, construction, and is therein grown and cultivated in the special and simple manner described by him; it will then, and only then, cease to be susceptible to the influences of its immediate habitat; (3) that its sensitiveness to atmospheric and electric influences can then, and under such conditions alone, be thoroughly controlled, and may then be turned to practical account for forecasting the local weather, with truly marvellous precision, 48 hours beforehand, and likewise earthquakes, or subterraneous disturbances, both at a distance and locally, with respectively three to eight days' previous notice.

Any number of weather plants placed under such conditions will behave alike. Such is Professor Nowack's experience, which extends now over more than four years, is based upon more than 34,000 different observations with hundreds of plants, and is, all in all, a matter of the deepest scientific study. In Austria the merits of the plant have been fully recognised by a great many who had originally approached the matter with the utmost disbelief and ridicule. The Archduke Reiner is a firm believer in the plant's merits, and has shown Mr. Nowack much encouragement in his work, and whole townships, agricultural unions, farmers, &c. have furnished testimonials to like effect. The observatory of the Austrian Tourists' Club, on the Sonnwendstein, at an altitude of 1,511 mètres, in the Styrian Alps, well known to many English tourists, which supplies the various branches of the club with weather forecasts during the season, has now for already over a year, discarded both aneroid and ordinary barometers for that purpose, and depends for its forecast upon the weather plant alone. The earthquake at Stolac, in Bosnia, on the 10th inst., which was so clearly and accurately forecast by the weather plant as early as the 2nd inst. at noon, and was thus mentioned in the "Times" of the 5th inst., must, moreover, be a conclusive proof to even the most sceptical that forecasts of great importance can be reliably ascertained by the aid of the weather plant.

I am, &c.

Clapham Common, S.W.,
November 13.

C. W. Radeke.

Little further was heard of the weather plant till July of last year when Mr. Nowack called at the Royal Gardens with the following letter of introduction on the part of H.R.H. the Prince of Wales.

Major-General Ellis to Royal Gardens, Kew.

Marlborough House, Pall Mall, S.W.,
13th July 1889.

Dear Sir,

The Prince of Wales desires me herewith to give a letter of introduction to you, to Mr. J. Nowack, an Austrian gentleman, who is anxious to make known his theory of the weather plant in England.

His Royal Highness, when in Austria, had his attention drawn to it by the late Crown Prince Rudolph who was much interested in its success.

Anything you can do to advise Mr. Nowack will be appreciated by H.R.H. the Prince of Wales, Mr. Nowack being an entire stranger in England.

Yours, &c.
(Signed) ARTHUR ELLIS.

W. T. Thiselton Dyer, Esq.,
C.M.G., F.R.S.,
Royal Gardens, Kew.

Mr. Nowack stated that he was anxious to place in the Royal Gardens some of his plants in the apparatus devised by him for weather prediction. His object was, no doubt, to make his invention known and so ultimately to promote the sale of the apparatus which he considered essential for obtaining predictions from the weather plant. Any trial or exhibition, however, which is directed to a commercial object is, for obvious reasons, not permitted in the Royal Gardens. Mr. Nowack was, however, perfectly willing to allow some of his plants to be deposited in the Jodrell Laboratory, and to demonstrate from day to day, over a sufficient period to allow of a fair trial, the predictions which he believed their movements afforded. It seemed desirable that this should be done. Experience has shown that most popular beliefs about natural phenomena have some substratum of truth at the bottom of them. H.I.H. the late Crown Prince Rudolph was no inconsiderable naturalist, and he must have thought that there was some *prima facie* case in favour of the weather plant. And the idea was not actually novel, as a plant of somewhat similar habit had been long ago regarded in South America as affording indications of changes in weather.* Nor is it intrinsically improbable that there should be some actual relation between plant movements and weather. The former, as will be seen, are largely due to external conditions, especially temperature and amount of sunlight. But these are actually part of weather, and the only real difficulty consisted in conceiving by what possible physical agencies a plant could anticipate beforehand the conditions to which it was to be subsequently subjected, and which it would, no doubt, at the time reflect.

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* Writing at the end of last century Ruiz and Pavon† describe in some detail the sleep-movements of *Porlieria hygrometrica* a Chilian Zygophyllaceous plant. *Porlieria* is a plant with shrubby habit and pinnate leaves somewhat resembling a *Mimosa*. The following is a translation of the passage in question :—"By day the "leaves are awake, at night they sleep (as is the case in many plants with pinnate "leaves); the primary and secondary petioles are then strongly drawn together, "adhering to one another in pairs so that the plant appears bare of leaves, "and, as it were, dried up. They predict fair and stormy weather: for if at "first the day breaks fine, they begin to unfold and after two hours are completely "expanded; in the evening, provided the following day is to be dry, they begin to "close up half an hour before sunset. But if the next day is going to be overcast "and stormy, they begin to close an hour before sunset, and in half an hour are "completely settled to sleep. If the following day is overcast and tempestuous, "the leaves begin to unfold after sunrise and are expanded in 1½ hours. But "should the plant be soaked by much rain having fallen since noon the leaves "completely close either a little before or after sundown. These phenomena were "at first frequently observed at Huanuco, but have been continually confirmed in "navigation from Peru to Cadiz."

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† Ruiz and Pavon. Systema veget. Fl. Peruvianae et Chilensis. 1798. pp. 95 and 96.

It would not have been easy for any member of the staff of the Royal Gardens to devote the time which would have been necessary to the daily observation which the experiment required. This task was, however, very kindly undertaken by Francis Oliver, Esq., F.L.S., D.Sc., Lecturer on botany at University College, London; and he has furnished the very full and able report upon the whole investigation which is now published.

In order to complete the documentary history of the weather plant, it will be convenient to quote from the specification of the patent taken out by Mr. Nowack, the preamble in which he states the exact nature of his invention.

"Date of application, 31 December 1887.
"Specification accepted, 12 October 1888.

"A.D. 1887, 31st December, No. 18,026.

"Complete Specification.

"A Weather Indicator.

"We, Joseph F. Nowack, manufacturing chemist, and Ernst Bahlsen, market gardener, both of Prag, in the Austro-Hungarian empire, do hereby declare the nature of our invention for 'a Weather Indicator,' and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

"Our invention is based on the discovery by the said Joseph F. Nowack, that the leaves of a certain tropical plant, '*Abrus precatorius*,' have the peculiar property of indicating by their position various changes in nature about 48 hours before the said changes occur. As shown by numerous observations with hundreds of such plants, any given position of the leaves corresponds always to a certain condition of the weather 48 hours afterwards, and is therefore a reliable means of predicting the same.

"It is necessary to remark, however, that certain conditions must be observed in order to cultivate Nowack's weather plant in such a manner that it can be used as a weather indicator. In order to obtain and maintain these conditions, we have constructed an apparatus which, in combination with the weather plant, constitutes the principal subject of our invention.

"The conditions for the successful cultivation of the weather plant are—

"1. A temperature of at least 18° Reaumur.
"2. Access of atmospheric air, with exclusion of wind.
"3. Protection against direct solar rays."

After setting out the nature of the indications furnished by the weather plant and the method of interpreting them, he concludes:—

"Having now particularly described and ascertained the nature of our invention, and in what manner the same may be performed, we declare that what we claim is—

"1. An apparatus for indicating in advance changes in nature, such as changes of the weather, magnetic and electrical conditions, by means of Nowack's weather plant (*Abrus precatorius*), said apparatus comprising a transparent vessel containing the weather plant, closed on all sides, protected against injurious external influences, and adapted to be internally ventilated and maintained at a temperature of at least

18° Reaumur, these being the conditions under which, in temperate climates, Nowack's weather plant answers the purpose of a weather indicator, substantially as described and illustrated."

W. T. T. D.

Report on Observations made in the Royal Gardens, Kew, upon Mr. Nowack's Weather Plant.

The plant *Abrus precatorius*, Linn., is a well-known tropical weed. Originally a native of India, it is now widely dispersed in tropical regions, including Mauritius, the West Indies, &c. It is a leguminous plant, with the habit of a shrubby climber. In the case of the plants used by Mr. Nowack, the young rapidly-growing shoots were cut in before requiring any support. Thus the production of lateral shoots and foliage was stimulated.

The seeds of *Abrus precatorius* are well-known as "crab's-eyes," and are used all over the world for decorative purposes. In India they are called *rati*, and are largely used by goldsmiths as weights, each weighing about $1\frac{3}{4}$ grains. It is stated that the famous Kohinoor diamond was first weighed by the rati, a word which is indeed supposed to have given origin to the jeweller's carat (Kérat, *Arab.*).

The powdered seeds are harmless when eaten, but rapidly produce fatal effects when introduced beneath the skin even in small quantity. They are used criminally in India in "Sui" poisoning, the object being to obtain the skins of the poisoned domestic animals. The poisonous action is due to the action of a proteid, *Abrin*.

The leaves of the plant are two to three inches long, with 10 to 15 pairs of shortly stalked leaflets. The texture of the latter is very delicate and membranous; the surfaces glabrous.

At the point of insertion of each leaf on the stem is a slightly swollen joint or *pulvinus*, and each leaflet is provided with a similar small secondary pulvinus at its point of insertion on the main rachis. The rachis as well as the leaflets perform considerable movements both vertically and laterally on their pulvini. It is with these movements that the bulk of this report is concerned, as on them Mr. Nowack bases his various weather prophecies and barometric charts.

The leaves are arranged on the stem *alternately* with for the most part a divergence of $\frac{1}{2}$, but since in its development a leaf generally bends round through an angle varying from a few degrees to as much as 90°, it is found on an adult shoot that the leaves point in various directions. They spread themselves so as to obtain the most favourable illumination. This point is of some importance and will be referred to later on.

I refrain from introducing histological details. But the mode of secondary increase in the thickness of the stem is peculiar and abnormal, as in many plants of climbing habit. The leaves, however, and the motile organs, the pulvini, do not differ in any character or manner from the same organs in other leguminous plants with motile leaves.

Some years ago seeds of this plant were communicated to Mr. Nowack with the statement that "they belonged to a wonderful flowering plant." He raised young plants from them and was much impressed with the movements of the leaflets and of the leaves. That the movements in question did not depend on the immediate external conditions, Mr. Nowack soon satisfied himself. His observations suggested to him the existence of some connexion between the movements and the state of

the weather at a future period. The views which his further observations led him to adopt are contained in his pamphlet, published at Prag in 1888, entitled "J. F. Nowack's Wetterpflanze, deren Eigenschaften, "Cultur und Pflege, mit Anleitung, wie durch dieselbe jegliche "Witterungs- und Temperatur-Veränderung für den *Horizont*, die "*Umgebung* und *Local* unbedingt verlässlich und genau 48 Stunden "vorher bestimmt werden kann."

Mr. Nowack claims to be able to foretell, 48 hours ahead, the nature of the weather and its various changes as well as the strength and direction of the wind, and rise or fall in temperature. Further, that intimation of the advent of earthquakes and of "Schlagwetter," (*i.e.*, escape of firedamp in coal mines) is given by the plants many days in advance.

According to Mr. Nowack, individual plants of *Abrus precatorius* fall into two physiogical groups; (1) the weather plants proper which he speaks of as B-plants, and (2) plants indicating coming changes in temperature, T-plants.

I will now shortly describe the chief movements performed by these plants and the significance attached to them by Mr. Nowack.

In the first place it is claimed that if plants of *Abrus* be allowed to grow undisturbed, the leaves as they develop will place themselves so that their axes lie in the chief planes of the compass N. and S., E. and W., *i.e.*, that all the leaves on a plant will point either N., S., E., or W. Further, if during its development a plant be turned through an angle, the leaves tend to move back to the four cardinal points.* It is by noticing to which side of a plant any given leaf in a phase of movement belongs that the direction from which the indicated weather change will come is ascertained.

The leaves on any healthy plant fall into three categories, according to their age. The oldest leaves of all indicate weather for the immediate locality only, to a distance of half a mile. Leaves of an intermediate age, from 5 to 10 miles; whilst the youngest leaves tell the weather for an outer zone to as great a distance as 50 miles. As the plant grows and develops fresh leaves, those which were a short while before the youngest, and which told the weather for the distant zone gradually pass over to the intermediate category, and indicate for the middle zone, and finally only for the immediate locality.

It must be remembered, then, that the leaves of different ages are sensitive to changes in the weather at varying distances from the point at which observations are being made. The manner in which these changes are indicated is the same in all cases. Thus, a thunderstorm to occur at the greatest distance is signalled 48 hours beforehand by the youngest leaves only; one for the immediate locality is in the same way indicated by the oldest leaves.

The movements shown by the leaves are of two different kinds:—

1. Movements of the leaflets.
2. Movements of the rachis (midrib).

As the two sets of phenomena are entirely distinct, and are used by Mr. Nowack for different purposes, I will treat of them in two separate sections.

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* I may say at once that I have been unable to confirm these statements. I observed closely the development of new shoots on many plants. The leaves as they were developed pointed in various directions, but not more to N., S., E., and W., than to intermediate points.

I. *Movements of the Leaflets.*

At night the leaflets hang vertically downwards, so that their under-surfaces are approximated. This is the sleep position. During the day the leaflets are more or less raised, making various angles with the vertical. Commonly during the day they approximate to the horizontal, or they may move upwards considerably beyond this, so that their upper surfaces are separated by an angle of only 45° or 30°, as, for instance, in direct sunlight. Those positions of the leaflets *below* the horizontal Mr. Nowack speaks of as "*negative*"; those *above*, as "*positive*." These "positive" and "negative" positions he regards as fundamental, and as indicating 48 hours ahead fine or wet weather respectively. The horizontal position is for *change*; and if the leaflets gradually move upwards from this position into a "positive" position, a forecast of the weather 48 hours ahead is make for "clearing up," "fair weather," or even "fine and cloudless," according to the intensity of the positive movement (as judged by the height to which the leaflets move). In a precisely similar manner a sinking of the leaflets indicates an "overcast sky," "probable rain," or "heavy rain," the position for the last being almost coincident with the sleep position.

All these movements may be performed with the axes of the leaflets at right angles to the main leaf-rachis (indicating calm weather), or the leaflets may be inclined forwards making angles of less than 90° with the distal part of the rachis. These angles are regarded as indicating the intensity of the wind; the smaller the angle, the stronger the wind. A "fresh to strong" wind is indicated by an angle of about 45°. These are combined with positive or negative or horizontal positions of the leaflets (pointing to "fine weather with wind" or "wet weather with wind," &c.).

The *direction* of the wind is obtained by noting in which direction the leaves affected by this particular phase of movement point; the changes in direction by noting the sequence in which this forward inclination of the leaflets appears on them.

Electrical disturbances are indicated in two ways:—(1.) By an irregular arrangement of the leaflets, some directed forwards, others backwards; some positive, others negative. This irregularity he considers to foretell "presence of electricity in the atmosphere," but not necessarily thunder and lightning. (2.) By a peculiar curving of the leaflets, each leaflet being convex above, concave below. This movement may be called "rolling" of the leaflets. This "rolling" is shown by leaflets for the most part in the negative position, and it thus often happens that whilst the secondary petioles of the leaflets may be inclined to one another at an angle of, say, 90°, their apices, being curved down so as to lie almost vertically below the leaf-rachis, will almost touch or even overlap. This "rolling" foretells thunder and lightning for the locality or some distance away, according to the relative age of the leaves on which it occurs.

Since his arrival in England Mr. Nowack has found that fog or mist is prophesied by irregular positions of the leaflets indistinguishable from that indicating "electricity in the atmosphere." The more strongly marked the irregularity the denser will be the mist. It is on account of this similarity of the indications that Mr. Nowack, in forecasting weather, has found himself unable to distinguish between "electricity" and "fog." This is the explanation of such dubious forecasts as that for October 31st.

A further movement, somewhat resembling the "rolling," is sometimes found. It is such that each leaflet affected is bent in an undulating manner, part of each surface being slightly convex, part slightly concave. This is the "snow" or "hail" position.

The above are the chief movements, &c. of the leaflets used by Mr. Nowack in forecasting weather.

Plants used for making forecasts are grown under specially devised glass shades admitting of being heated from below, and allowing a ventilating current of air to circulate. The apparatus is needed for plants growing in the open or in an ordinary room, as the temperature should never fall much below 18° R. At Kew the plants under observation were placed in a stove, so that extra heating was not necessary. In practice, even in a stove, the glass shades were always retained, as Mr. Nowack considered that more reliable forecasts could be made with them. The plants were always protected from the direct rays of the sun by thin gauze screens, as direct sunlight seriously injures the foliage. In cloudy weather the screens were always removed.

I insert now, without further preliminary discussion, a series of Mr. Nowack's "weather forecasts," as they were given to me by him from day to day. Side by side with each "forecast" is given the actual state of the weather as taken down by me or my assistant, Mr. Weiss, from day to day.

Forecast for Oct. 7th. Drawn up Oct. 5th. (Originally given for 6th.)		Actual Weather Oct. 7th.	
9.30	Overcast.	9—9.30	Fine.
10.30	Fair to fine.	10	Heavy shower.
12	Fine.	10.45	Shower.
1	Fair.	11.45	Fair to overcast.
2.30	Overcast, rain?	12.30	Fine.
3	„	2	Light shower.
4	Clearer.	3	Fine to fair.
5	„	3—5	Fine to overcast; strong winds.

Forecast for Oct. 9th. Drawn up Oct. 7th.		Actual Weather Oct. 9th.	
9.10	Fine to fair.	9—1	Fine to fair.
11	Change.	2—5	Fair to fine; not clouding over later.
11.30	Fair to fine.		
12	Change.		
1—5	Fair to fine.		
Later	Overcast and showers.		

FORECAST for Oct. 10th.

Drawn up Oct. 8th.

(Originally given for 10th ; then altered to 12th; but finally standing as above.)

10 Fine.
12 Fair to overcast; some heavy clouds in S.W.
1—30 Overcast; haze or mist.
1.45 Shower.
3 Rain and mist (distant).
3.30 Rain; heavy at some distance N.W.—S.W.
5 Rain.

ACTUAL WEATHER Oct. 10th.

Fine morning, with few cumulus clouds.
Fine afternoon.
Fine evening.
No rain all day.

FORECAST for Oct. 11th.

Drawn up Oct. 9th.

(Originally given as above; then altered to 15th; but afterwards standing as given.)

10 Fine.
11 Overcast; slight mist.
12.30 Rain.
1—1.30 Shower.
2.3 Rain.
4 Shower.
5 Overcast.

ACTUAL WEATHER Oct. 11th.

Morning till 12.0 Fog, and continuous drizzle.
12.30 Clearing.
3.0 Overcast to fine.
Fine after 3.30.

FORECAST for Oct. 12th.

Drawn up Oct. 11th.

(Originally given for Oct. 13th.)

Morning overcast; rain at 9.30 and 12.
1 Fair.
2.30 Overcast; shower.
3.30—4 Overcast; rain in places. Heavy rain and thunderstorms in W.
4 Clearing.
4.15—5 Fair to overcast.

ACTUAL WEATHER Oct. 12th.

Morning fine and cloudless till 1.
1—2 Clouding up.
Slight shower 2.15.
3—and onwards. Absolutely fine.
No rain or thunder.
Slight mist in evening.

FORECAST for Oct. 14th.

Drawn up Oct. 12th.

(Originally given for 14th ; then altered to 13th ; but finally standing as originally given.)

9.30—1 Fine.
1.30—4.30 Change and rain.
Evening Fair to overcast.
Wind Fresh to strong in morning.
Mist and fog in afternoon at places.

ACTUAL WEATHER Oct. 14th.

9.30—1 Misty to fine.
2—5 Fine, with an occasional cloud.
Evening Fine.
No wind in morning.
Some mist at 5.
No rain in England all day.

FORECAST for Oct. 15th.

Drawn up Oct. 14th.

10—1.15	Fine, with clouds later.
2.45	Fair to fine.
3	Fog or thunder in neighbourhood.
3.15	Fair; showers in places.
4—4.30	Fair to fine.

ACTUAL WEATHER Oct. 15th.

10—2	Fair; clouds at times.
2—2.45	Heavily overcast.
3—5	„ „
	No thunder in neighbourhood.

FORECAST for Oct. 16th.

Drawn up Oct. 13th.

1.30	Very fine; moderate wind.
2	Overcast.
2.30—3	Rain.
4	Clearing to fair.
5	Fair generally; a few clouds.
	Fresh winds in afternoon.

ACTUAL WEATHER Oct. 16th.

1.30	Heavily overcast and rain.
2	Steady rain, continuing till night.
	No wind.
	Thunder reported in S.W.

FORECAST for Oct. 17th.

Drawn up Oct. 15th.

9.15	Mist to fog; clearing.
11	Fine; wind rising; some mist.
11.15	Fine.
12—1	Overcast; local showers in N.W.
1—2	Fair; wind increasing.
2—3	Fair to overcast; rain locally.
4	Overcast; showers.
4.30	More rain or clouds.

ACTUAL WEATHER Oct. 17th.

9.15	Fine; no fog or mist.
11	Fine; calm.
12—1	Fine; cumulus clouds.
1.30	Fair; calm.
2—3	Overcast.
4	Overcast to fair.
4.45	Fair; some clouds; no wind all day.

FORECAST for Oct. 18th.

Drawn up Oct. 17th.

9—1	Fine.
1—2	Overcast.
2.30—3	Perhaps showers; mist.
3—5	Clearing to fair.
	Fair later; no rain.

ACTUAL WEATHER Oct. 18th.

9—12.15	Fair to overcast; heavy clouds.
12.40	Fair.
	Afternoon overcast, with rain after 3; wet evening.

FORECAST for Oct. 19th.

Drawn up Oct. 16th.

9.0	Fair to fine.
10.30—11	Overcast.
12	Changeable; overcast to fair; little rain locally.
1—2	Overcast to fair.
2—3	Rain.
4	Rain.
5	Hail locally.
	Thunder in E. district; clearing.
5.30	Fair.

ACTUAL WEATHER Oct. 19th.

9—10	Overcast.
10.30—12.30	Rain.
	Heavy after 12.
1.15—2.30	Fair; some clouds.
3.15—3.30	Shower.
4	Fair.
	No hail or thunder.
	Wind increasing after midday.

FORECAST for Oct. 20th.

Drawn up Oct. 18th.

10	Change to fair.
12	Fair to fine; moderate wind; some mist in N.
1—2	Fair; overcast at times. Heavy thunder clouds in N.W.
3—5	Overcast; no rain.

ACTUAL WEATHER Oct. 30th.

10.45	Rain.
1	Rain.
Afternoon fair to fine.	
5	Overcast and rain. Snow reported in Scandinavia.

FORECAST for Oct. 21st.

Drawn up Oct. 19th.

9.30—1.30	Generally overcast; less cloudy towards 1.
2	Fair; misty to foggy. Snow in Scotland or W. England.
3—4	Fair to fine; probably cloudless; wind freshening.

ACTUAL WEATHER Oct. 21st.

9.30—12	Rain; heavy about 10; some mist.
1	Overcast and foggy.
1.45	Gloomy and foggy; heavy rain.
2	Overcast.
3	Overcast to fair; some mist; no wind. Thunderstorms reported in West and North.

FORECAST for Oct. 22nd.

Drawn up Oct. 21st.

(Originally given for 23rd.)

9	Rain?
11	Overcast; mist.
11.30	Clearing.
1	Overcast; rain? fog increasing.
1.45	Gloomy; heavy rain.
3	Clearing.
3.30	Changeable to fine; thundery clouds.

ACTUAL WEATHER Oct. 22nd.

Dull and misty all day.
No rain.
Thunder and lightning reported in Channel.
Snow in Scandinavia.

FORECAST for Oct. 23rd.

Drawn up Oct. 22nd.

(Originally given for 24th.)

9·45	Overcast; some mist.
11.30	Mist to fog.
12	Fog increasing.
2—4	Rain and fog. After 4 less rain, but more fog.

ACTUAL WEATHER Oct. 23rd.

9—10	Overcast; no mist.
11.30	Rather brighter.
12	Overcast.
1—4	Overcast; no fog or rain After 4 lighter; no fog.

FORECAST for Oct. 24th.

Drawn up Oct. 20th.

(Originally given for 22nd.)

9.30	Overcast. Rain? slight mist.
10	Overcast; slight mist.
11	Fair; then heavy rain and mist.
12.45	Change to fine.
1.30	Fine.
4.30	Cloudy at times.
5	Fine.

ACTUAL WEATHER Oct. 24th.

9—11	Dull; bright above.
11—12	Fair; no rain or mist.
12	Fair to fine.
1.30—5	Fine and cloudless. Slight mist after 5.

FORECAST for Oct. 25th.

Drawn up Oct. 23rd.

9	Fair; cool; mist.
11	Overcast.
12.30	Fair to fine; heavy clouds beginning.
2	Heavier clouds; dull; rain in places; overcast; mist.
5	Clearer in places; for most part overcast, with heavy clouds; misty. Thunderstorm; S. to S.E. and N.N.E. at some distance.

ACTUAL WEATHER Oct. 25th.

10—1	Fair to fine; no mist; cool.
1	Fine.
2	Fine; few cumulus clouds.
3—5	Cloudless. At 5 a few clouds to S.S.E.
5.30—8	Fine; no mist. No thunderstorm in district.

FORECAST for Oct. 26th.

Drawn up Oct. 24th.

9.30	Overcast.
10.30	Fair to fine.
11.30	Wind light.
1.30	Overcast.
2.30	Thundery; dull, perhaps rain wind moderate.
3—4	Foggy; heavy clouds; rain ?
4.30	Clearing to fair; some mist.

ACTUAL WEATHER Oct. 26th.

9—10	Overcast to fair; wind fresh.
10.30 12.30	Overcast; some mist at 12.
1.30	Wind, fresh to strong.
3 5	Overcast. Wind increasing; closing up.

FORECAST for Oct. 27th.

Drawn up Oct. 26th.

(Originally given for 28th, then 29th, and finally altered to 27th.)

9.30	Overcast; no rain; wind moderate.
10	Change to fair.
12	Fair to overcast; wind moderate to fresh.
1	Dull; showers.
3	Dull; rain in places; wind fresh.
3.45	Overcast.
4.30	Change to fair.

ACTUAL WEATHER Oct. 27th.

9—1	Heavily overcast; with continuous rain. Wind E.; fresh; mist.
2.30	Dull; still raining.
3	Rain ceased; wind light.
4 —4.30	Dull, with occasional breaks; clouding over at 5.

FORECAST for Oct. 29th.

Drawn up Oct. 25th.

(Originally given for 27th.)

9.30	Fine; wind moderate.
12	Fine, with fog to N.N.E.
1.30—2.30	Clouds; fair to fine.
3	Fine; fresh to strong wind; thunder clouds; thunderstorm { or / and } fog in S.W.
4	Dull; heavy showers; thundery; colder.

ACTUAL WEATHER Oct. 29th.

	Dull till evening; calm.
4	Clearing.
5.15	Stormy; $\frac{1}{3}$ clear.

Forecast for Oct. 30th. Drawn up Oct. 29th.		Actual Weather Oct. 30th.	
10	Clearing up; slight mist.	8—9	Very fine; no mist; calm.
10.30	Fair to fine; mistier.	10.15	Fine; calm; no mist.
1.15	Changeable; fair to overcast.	11	Cumuli on horizon.
3	Overcast; heavy clouds; misty.	12	Fair; light winds.
3.30	Overcast; heavy clouds.	12—2	Fair to overcast.
5	Fair.	3	Fair to fine; few clouds; no mist.
		3.30	Fair; more clouds.
		4	„ „

Forecast for Oct. 31st. Drawn up Oct. 28th. (Originally given for 30th.)		Actual Weather Oct. 31st.	
10	Rain; mist.	10	Fine; cloudless; no mist.
10.15	Clearing; more wind.	10.15	Ditto—calm.
12	Fair to fine.	11	Ditto.
2	Changeable; clouds increasing.	12	Fine; few light cumuli to N.
3	Heavy clouds; dull; thunder *or* mist and fog.	1—5	Cloudless sky; no mist.
4.45	Overcast; showers at times.		
5.15	Overcast; fair in places.		

Forecast for Nov. 1st. Drawn up Oct. 31st.		Actual Weather Nov. 1st.	
9.30	Fine.	9.30	Overcast; heavy rain.
12	Fair.	10	Fair.
1	Fair to fine.	10—12	Fair to fine.
2	Overcast.	12—4	Absolutely fine, with an occasional cumulus cloud.
4	Changeable; fresh wind.	4—6	Clear; calm.
4.45	Fair to fine.		

Above stand the forecasts and actual weather, side by side, between October 7th and the beginning of November. One or two days alone are wanting, on which, for some reason, either no forecast was forthcoming or no record of actual weather taken. The reader can judge for himself as to their value as weather forecasts.

In about half the cases (11 out of 23) given, the final determination of the day for which the forecast was made out was only made *after the event*. The frequent changes were due to several causes. Sometimes the barometric charts had to be re-arranged to procure even a colourable resemblance between the actual and prophesied *charts*, and this necessitated a re-arrangement of the corresponding weather forecasts (which, however, were made independently of the charts). Sometimes, in like manner, the prophesied and actual *weather* were at variance, and a change would be necessary in the forecasts. The weather forecasts are given for the day finally fixed, but where a change had been made after the event the fact of such change is given in brackets.

In describing Mr. Nowack's method of forecasting weather I said that, normally, the plant is supposed to foretell two days ahead. This is the method described in his pamphlet, and this is the method used by him in the published samples of his forecasts. As a matter of fact, a large per-centage of the weather forecasts which he now makes are not

drawn out two days, but some other number of days ahead. It will be seen that of the forecasts just quoted only 10 (under one half) are two days ahead, and the others, one, three, four, &c., days ahead.

To take a succinct case :—

On October 19th	the plants	foretold	weather	for	the 21st
„ 20th	„	„	„	„	24th
„ 21st	„	„	„	„	22nd
„ 22nd	„	„	„	„	23rd
„ 23rd	„	„	„	„	25th

On October 19th one of the numerous "changes" took place, and for three days the plant ceased to foretell two days ahead. On the 19th the forecast was for the 21st, whilst on the 20th it jumped to the 24th, and on the 21st back to the 22nd.

Very few of the "changes" in October were anticipated by Mr. Nowack—indeed, only one. They were needful in order to make the prophesied and actual weathers and the prophesied and actual barometric charts fit to a certain extent. I cannot say that the series of weather forecasts above given, arranged, as they are, in the order most favourable to Mr. Nowack, show any great advance on methods already in use.

From the moment I had these plants under observation I was much impressed with the extraordinary sensitiveness of their leaflets to alterations in the intensity of the light, and the view which I first formed as to the nature of their up and down movements was, in the main, that they were called forth by fluctuations in the intensity of the light. All through I have failed to notice anything to shake this opinion.

On a fine bright morning the leaflets stand in such a position that their upper surfaces make an angle of 90° or less with one another, and if the day continues fine this position is more or less maintained till well on in the afternoon. A cloud obscuring the sun's face for a brief period is sufficient to depress the leaflets from their high position to the horizontal. On Mr. Nowack's method, should the depression reach, for instance, some distance below the horizontal a forecast would be made of clouding up, or even a shower, to occur 48 hours afterwards.

After studying the movements of the leaflets continuously for some days, it was possible to say with some certainty before visiting the plants what would, on the whole, be the position of the leaflets. Of course individual plants differed to some extent, some being less, others more sensitive to variations in the intensity of the light. The so-called T-plants (regarded as foretelling changes in temperature) are especially sensitive, a lesser degree of brightness sufficing to bring them into a strong positive position than is the case with the ordinary B-plants. Similarly it is the T-plants which first intimate a decline in the light-intensity as in the afternoons. Indeed Mr. Nowack separates the T-plants by noting day by day which go to sleep first in the afternoons. The positions of the leaflets on different sides of the same plant are dependent on the illumination. Thus to take the case of a plant lighted from one side; whilst the leaflets which are better illuminated show positive positions of varying degree, those on the shady side will be horizontal, or even in negative positions. In showing that these movements are called forth by light, I am not demonstrating any new property of plants. This action of light on many Leguminous plants has long been a well-known fact to vegetable physiologists, and for a more detailed description of continuous observations reference should be made more especially to the work of Pfeffer and of the Darwins. *Abrus precatorius* without doubt shows sleep movement, which differs only in degree from that of *Robinia*

Pseudacacia. In both the plants a change from a weaker to a more intense light calls forth the strongly elevated (or "positive" position) of the leaflets, whilst one from a more intense to a weaker light, a movement of the leaflets downwards (into the "negative" position). These plants differ from many Leguminosæ in that they possess distinct light and dark positions. As the intensity of the light is augmented, the leaflets go on moving upwards till their further progress is arrested by the approximation of the upper surfaces of their pulvini. In many other Leguminosæ, of which *Averrhoa Bilimbi* may be quoted as an instance, the leaflets hang vertically downwards in darkness. With increasing light they gradually move up to a horizontal position. When, however, the intensity of the light is increased beyond a certain limit, the leaflets, instead of continuing their upwards movement, begin to fall again and hang vertically downwards as in direct sunlight. Here then the extreme light and dark positions are identical. There are other types of movement in allied plants into which I need not enter here.

Between the more sensitive so-called T-plants and the ordinary B-plants, all intermediate degrees of sensitiveness occur. In any batch of seedlings a large number of slight physiological varieties seem to occur, some exhibiting greater sensitiveness to light than others. It is the extreme forms that are roughly classified respectively as B- and T-plants. Mr. Nowack is inclined to think that the intermediate forms pass over later on into one class or the other. Whether this is so or not, I am not in a position at present to say.

Not infrequently I noticed on certain plants groups of leaves, either on a particular shoot or at the base of the main axis, the leaflets of which exhibited very sluggish movements, and indeed never assumed a positive position, except in direct sunlight. I am inclined to regard these leaves as indicating an improper treatment of the plants bearing them, since in several cases in which the treatment was altered, they behaved similarly to, and were indistinguishable from, the other leaves of the plant.

Seeing then that the movements of the leaflets are for the most part controlled by variations in light intensity one can see how the weather plant may, under special circumstances, serve as a true weather prophet. If the weather is continuously fine or continuously wet the plant will in the former case continuously prophesy fine, and in the latter, wet weather. This is because fine weather is bright weather, and light of a strong intensity promotes the "positive" position, whilst wet weather is dull weather, and a weaker light promotes the "negative" position. So long as the weather day after day is constant, a correct forecast will be given, it matters not whether 2 or 10 days ahead. The difficulty is to tell when the fine weather will break up, or the wet weather give place to fine.

I will now consider the positions which Mr. Nowack regards as premonitary of electrical disturbance, snow and hail, mist and fog.

"Electricity in the atmosphere" is indicated by *irregular* positions of the leaflets, some being positive, others negative or horizontal. The electricity need not, however, manifest itself in the form of a thunderstorm. The same irregular position likewise indicates mist or fog; mist if only slightly shown, fog when more marked. A thunderstorm is indicated by a bending of the leaflets so that the upper surfaces are convex, the lower concave. I have noticed a tendency for this phenomenon to recur on the same leaves, and I regard it as a pathological phenomenon, but cannot assign a definite cause for it.

The irregular "fog-position" accompanies especially varying lights, and is prone to occur on plants whose environment is interfered with

in certain ways. If a plant be darkened for some hours and then exposed to the light and darkened again, &c., this irregular position of the leaflets will be called forth; the same thing will happen if the plant be inverted for a few hours. Unhealthy plants are more apt to show it than well-grown ones.

On any leaf probably all the leaflets are not sensitive in absolutely the same degree, and sudden fluctuations in the conditions producing movements will make this want of equality apparent in the irregular position of the leaflets.

Snow and hail positions are characterised by a slightly irregular transverse or saddle-shaped bending of the laminæ of the leaflets. When this position was first shown on a leaf (end of August) Mr. Nowack regarded it as indicative of electricity. Since, however, he has modified his view, and regards it as the precursor of snow or hail. My observations are briefly stated. When the peculiar curvature in question appears on a leaf, it remains permanently, at any rate in all cases coming under my notice. For example: the leaflets on a few leaves show these curves to a marked degree during the last week in August past. They remained on these leaves till the middle of October, when the leaves were removed from the plant. The same occurred in other cases. I have found that this phenomenon is usually associated with a peculiar spotting or bleaching at the margin of each leaflet affected near the apex. Whether this spotting is due to the puncture or bite of some insect, I cannot certainly say. However, my observations point to a connexion between the spotting and the curvature. The leaves possessing a sweet taste, not unlike "liquorice-root," they may not improbably be punctured by insects.

II.—*Movement of the Rachis* (*Midrib*).

Previous to his sojourn in England Mr. Nowack would seem to have devoted little attention to the movements of the rachis of the leaf, except those extreme positions which he regards as indicating earthquakes and schlagwetter. Recently, however, he has observed these more closely, and attaches to them very great importance indeed. It must be stated at the outset that these rachis-movements are entirely independent of the movements of the leaflets. At the time when his pamphlet was issued (1888) Mr. Nowack attached special importance only to certain extreme and well-marked rachis positions, in addition to the leaflet movements. These were:—

(1.) Cases in which the rachis is bent sharply down from the pulvinus, making an angle of 45° or less with the stem. Such as these are earthquake positions, and the distance of the shock is roughly indicated by the extent to which the leaf apex is bent down; in the case of an earthquake for the immediate vicinity the leaf will be bent down, becoming almost parallel to the stem.

Earthquakes, as well as mine explosions, are indicated for much greater distances than ordinary weather changes. The forecast is only taken after the maximum of bending is reached, and the earthquake may occur some days, or even weeks, after the arrest of further downward movement. At that time, if I apprehend Mr. Nowack aright, the date of occurrence of the event could not be more than roughly indicated; later, however, he modified his former views, and constructed a fresh hypothesis to be detailed below.

The direction of the earthquake is indicated by the quarter of the compass towards which the affected leaf points.

The schlagwetter position resembles the above position except that the leaf-rachis is not bent sharply from the pulvinus, but at first is directed upwards a short distance, and the distal two-thirds curved sharply downwards. The forecast is drawn from it in much the same manner as for earthquakes. It is a significant fact that leaves after assuming the "Schlagwetter" and earthquake position, do not straighten out again, but always die. This will be referred to later on.

In addition to the strongly marked positions just described a little observation shows that each leaf is continually oscillating slowly on its main pulvinus. Sometimes the rachis is more or less horizontal; at other times it is inclined upwards or downwards to a greater or less extent. In a single day I have known a leaf to move through as large an angle as 20°—25°. During his stay at Kew, Mr. Nowack elaborated an ingenious method for predicting from these movements of the rachis the position and course of regions of barometric depression and of anti-cyclones. From day to day he sketched out and placed in my hands synoptic charts of barometric high and low pressure for, generally speaking, three days in advance. These charts cover the same area as the daily charts issued by the Meteorological Office in their daily weather reports. Mr. Nowack claims that from these charts forecasts for wind and weather can be made out at least a day or two ahead.

Altogether Mr. Nowack has drawn up in this way between 50 and 60 barometric charts, which he was anxious should stand the test of comparison with the actual charts for the corresponding time, as drawn up at the Meteorological Office. On these charts I will not pass any criticism, as Mr. R. H. Scott, the secretary to the Meteorological Office, has kindly undertaken to do so.

It may, however, be of interest to explain briefly the general method by which these charts were prepared.

As already mentioned barometric readings are taken solely from the inclination of the leaf-rachis to the stem. Speaking generally an upwardly inclined rachis indicates low pressure, a downwardly inclined one high pressure. The degree of pressure is indicated by the angle made by the rachis with the horizontal. Thus, in the case of a leaf pointing obliquely upwards, if it makes an angle of 45° with the horizontal, a considerable depression is indicated at a certain distance in the direction in which the leaf points; on the other hand, if the leaf-rachis makes only an angle of 18° with the horizontal, a much less marked point of depression is indicated.

Similarly, as regards high-pressures, except that the leaf rachis points downwards instead of upwards, the further the leaf is from the horizontal the greater the pressure indicated.

As with the weather prognostics, so here also, leaves of different ages indicate for different distances from the point of observation. However, while the older leaves indicate only local *weather* (to a radius of 5 to 10 miles) they indicate *barometric pressure* to a distance of 50 to 100 miles, and the youngest, which indicate weather at a radius of 40 to 50 miles indicate barometric pressure at a distance of many hundreds of miles. Taking readings from a plant consists in noting the inclinations (whether in the anticyclonic or cyclonic positions), the directions and the relative ages of a great number of leaves. The inclinations are marked 1, 2, 3 up to 6, high or low pressure, according to the deviation from the horizontal. 1 high or 1 low being the

strongest points, form the central points of high or low areas; 6 high or low would deviate but little from the horizontal and indicate the boundary of high and low pressure areas. A blank chart is then taken and circles drawn with the point of observation as centre. The inmost circle includes all points indicated by the older leaves, the second with radius of perhaps 200 miles those by leaves of intermediate ages, and an outer circle those by the youngest leaves. The values given by each leaf are then inserted on the map at their proper distances from the central point, and in the directions in which the individual leaves pointed. The approximately identical points are then connected in the same manner, as are equal points of barometric pressure, and the configuration of the figures so obtained indicate the different areas of high and low pressure. In practice Mr. Nowack uses blue for all points of higher, and red for points of lower pressure, and these are joined by "isobars" in the same colours, so that the regions of high and low pressure are at once apparent on examining his charts. Mr. Nowack does not claim to tell the *absolute*, but only the relative barometric pressure at the points marked. However, this does not affect the correctness of the barometric charts in any way, assuming the relative barometric heights to be indicated correctly. He distinguishes between deeper or shallow areas, the former having a centre marked 1 or 2, the latter say 3 or 4.

As a matter of fact it often occurs that points of high or low pressure fall on the chart near together. Suppose, for instance, points of low pressure are marked on a region over which the prevailing points are of high pressure, if practicable these will be joined to a near lying area of depression, indicating thus an off-shoot of that depression projecting into the anticyclonic area. But if the distribution of points of pressure does not admit of this, the isolated low pressure points must be neglected (as frequently Mr. Nowack did in his earlier charts) or they stand for some isolated areas of low pressure on a general high-pressure area. In any case some ingenuity is required in drawing the "isobars" so as to avoid great confusion; and in general Mr. Nowack's barometric charts are characterised by the complex (branched) figures of his different areas, and by the relatively large number of his primary and subsidiary centres. As I have said above, reference must be made to Mr. Scott's report as to how far they represent the real state of affairs.

I said that *on the average* the charts were drawn three days before the event, *i.e.*, a chart drawn from observations at noon on Tuesday should indicate the actual distribution of pressure at noon on the following Friday.

As a matter of fact, though Mr. Nowack professed himself often satisfied as to the agreement of his charts with the actual barometric charts, it often also occurred that they bore no sort of resemblance to the real chart of the day for which they were drawn up. When this happened it was necessary to change the order of the charts, and to assume that for the day in question the plants had not indicated three days ahead but two, four, or five days ahead, and the charts would be re-arranged so as to fit in most accordantly with the real barometric charts.

In speaking of the weather, I explained that local weather is not foretold with regularity, as described in his pamphlet, two days ahead, but at intervals of one, or three or four days ahead, as dictated by previous experience. Thus, usually on Monday the plant indicates weather for Wednesday and barometric pressure for Thursday; if, however, the chart made from the plant for Thursday does not match the actual Thursday's chart, that chart is regarded as being that for Friday,

and if it shows a certain agreement with the actual chart of Friday, this change is made. This implies also a shifting of the local weather-forecast in the same sense, and the weather forecast made on Tuesday for Thursday would also be changed in favour of Friday. In this manner, in order to harmonise the charts, the weather forecasts have had to be altered, and also on some occasions, in order that the prophesied may harmonise with the actual weather, a further re-arrangement has been necessary involving a second change in the charts.

These re-arrangements were found necessary oftener than Mr. Nowack anticipated, and in the month of October there were altogether five sets of changes, each including on the average three days. He was guided in the determination of the dates of these changes chiefly by the fact that the prophesied and actual charts failed to agree on the ordinary three days' system, and as a matter of fact during the month of October about 50 per cent. of the charts were given for days other than those to which they were finally ascribed. It was only *after the event*, *i.e.*, after receipt of the Meteorological weather report and chart for the day that a change was made. In having assigned to them the dates they bear, Mr. Nowack's charts are presented in the light most favourable to him. In each case where such a change has been made I have recorded both the date for which the chart was originally given as well as that to which it was finally relegated. How far the charts, *even when arranged in this revised order*, give the actual pressure changes over the area in question may be gathered by reference to the report on the question from Mr. R. H. Scott. I have only to say here that they bore the dates finally selected by Mr. Nowack when they passed into Mr. Scott's hands.

In view of the very great importance attached by Mr. Nowack to the curvatures and movements of the rachis, I have had the leaves on many plants under observation for a week or more at a time. Exact readings of their position were taken every two or three hours from 8 or 9 a.m. till late in the evening. Every day each healthy leaf on a plant performs considerable oscillations, and the record of these movements has been kept by a method similar in principle to that used by the Darwins and described in the first chapter of their "Movements of Plants." Plants under observation were placed within glass cases, each case having four plain sides fixed in a square framework. The movements of leaves parallel to any face were accurately followed by making, in the first place, small marks with white paint on the back and front glasses of the case, so that two marks and the pulvinus of a leaf stood in a straight line; the mark on the front glass covering the pulvinus in each case.

Arranging the plants so that as many leaves as possible have their midribs approximately parallel to two of the four glass sides, their movements of depression and elevation can be accurately followed. Points must be made on the parallel glass faces so that the pulvinus of every leaf under observation lies in a straight line with points on parallel glass faces. A line is then traced on the glass covering the midrib of each leaf; the eye of the observer being always so adjusted that the pulvinus of the leaf in question is pierced by the imaginary line joining the two points above mentioned.

By drawing such lines every few hours the vertical movements of the rachis are accurately recorded, and by using paint of different colours for successive days the movements over a considerable interval of time can be recorded on the same glass sheet without fear of confusion. When necessary these records can be traced off on to paper, and plotted out in a very simple manner into continuous curves.

Lateral movements may be similarly recorded on a horizontal sheet of glass fixed above the plant.

In this manner the movements of a very great number of leaves have been followed. The result of examination of a great number of such readings is to show that normally the rachis begins to move upwards between 10 a.m. and noon; that this upward movement is continued for about twelve hours, *i.e.*, till between 10 p.m. and midnight, and that then the rachis moves slowly down, reaching its lowest reading between 10 and 12 next morning. In an entirely normal case, in which the conditions of illumination and temperature are fairly constant from day to day, the curve of one day agrees with that of the preceding or following days, the leaf being approximately at the same inclination at the same time on successive days. A single leaf oscillating about the horizontal in a single day will at one time (morning) be in a position indicating (according to Mr. Nowack) relatively high barometric pressure, and later on in the same day in a position indicating relatively low barometric pressure.

Though all the leaves show such a diurnal movement of the rachis, all have by no means an average horizontal position; some permanently point upwards, others downwards. Those pointing upwards will be nearer the vertical at night and nearer the horizontal in the morning; those pointing downwards, on the other hand, will be nearer the horizontal when at their maximum height (*i.e.*, at night), nearer the vertical in the morning. All the leaves on any plant move in the same direction and reach their greatest heights or depressions at the same time. The mean position of a leaf seems to be that position in which it will receive the most adequate illumination. This is strikingly shown when a plant is submitted to onesided illumination, as in an ordinary room. The leaves of a plant on the side towards the light will for the most part bend downwards into extreme "high-pressure" positions, so as to place the upper surfaces of its leaves as far as possible at right-angles to the general direction of diffuse light. After remaining in this position for some time (a few weeks) this steep position becomes more or less fixed, so that if the plant be turned completely round through 180°, the position is not markedly altered. In the case of a leaf bending from a mean horizontal to a mean downward inclination of 60°, in response say to a onesided illumination, the change of position is gradually achieved by successive sinking day by day, and failure to rise to the original elevation. Hence a leaf at first oscillating about a horizontal plane will after a time, step by step, be found oscillating about a steeply inclined plane.

Other leaves, again, to accommodate themselves to light requirements will become elevated in a similar manner.

When the illumination is not of a constant character, as when a dull day is succeeded by a fine and cloudless day, and that again by a gloomy one, the extent of these daily movements is slightly modified. On a fine clear morning the downward movement is much greater than on a dull gloomy morning. The more intense light acts as an increased stimulus and the difference between the lowest day-position and highest night-reading is much greater in clear than in dull weather.

This was especially well illustrated by the behaviour of leaves on a number of plants under observation at the end of October. The mornings of October 27, 28, and 29, were dull and rather foggy, whilst those of the 30th and 31st were very bright and clear. November 1st was dull in the morning though brightening up later on. The mapped out curves covering the same period show that on the 27th, 28th, and

29th (dull days) the leaves on a number of plants performed similar movements, reaching almost identical highest and lowest limits each day. On the 30th (bright) the movement in the morning hours was continued down much further than on the preceding days; the tips of the leaves being as much as $\frac{4}{5}$ in. lower than at the same time on the previous day. Likewise on the 31st (also a bright morning) the lowest readings were (as on the 30th) considerably below the average. November 1st was a dull morning clearing later. The downward movement did not extend beyond the normal, and by the time the day cleared up the downward movement of the leaves had been arrested.

The extreme downward movement on a bright morning is not the result of a longer continued descent, but rather of the more rapid movement stimulated by the stronger light, since on fine and dull mornings alike the lowest point attained is reached approximately at the same hour. In other words, on a bright morning the movement downwards is not continued to a later hour but is more rapid, and continuing over the same time necessarily lower.

At night the extreme highest point is reached before midnight. Slight variations were noticed in the height attained on successive nights by individual leaves. I consider temperature to be at any rate one important factor affecting the movement.

The heating arrangements of one of the conservatories in which some of the plants were placed were such that whilst on some nights the temperature would be as high as 27° to 30° C., on others it would fall to 19° to 20° C. My experience is that, other things being equal, a leaf will move upwards more rapidly on a warm than on a cold night, and that consequently a higher point will be attained. As regards effect of varying humidity of the air, it would appear that in a drier atmosphere the movements are greater than in a more humid one.

The movements of the leaf-rachis in plants placed for a series of days in entire darkness is entirely consistent with the phenomena above detailed. For the first day or two after being placed in total darkness the leaflets remain folded in the sleep-position, and the fluctuations of the rachis are small and irregular. Soon the plant begins to recover from the effects of this sudden change of conditions, and each day for several hours between 10 a.m. and 3 p.m. the leaflets are raised to above the horizontal position. The action on the plant of continued alternation of day and night during its development would seem to have become impressed upon its organisation, so that it still responds spontaneously, though the external conditions have ceased to operate. This is of course no new fact, but one well known to plant physiologists. The recovery of the plant from the first shock, and the renewal of the periodic opening and closing of its leaflets in darkness is accompanied by corresponding movements of the rachis. Each day the rachis rises slightly during the afternoon and evening, and falls again during the morning. But the upward movement always exceeds the downward, so that the lowest point attained on any day is higher than the corresponding lowest point on a preceding day. In this way leaves which at the beginning of the experiment pointed downwards, making an angle of 45° with the stem, were often found to have risen in the course of a week to such an extent that they pointed upwards, making an angle of 135° with the stem immediately below their insertion. A curve of the movements of any leaf of a plant placed in darkness shows, after the first day or two, a continued gradual rise of the leaf, though for each day there are subsidiary small secondary curves indicating the diurnal movements whose permanence, now the plant is grown in

total darkness, is probably due to causes similar to those producing the daily movement of the leaflets.

Again, plants grown and illuminated only by light rays of low refrangibility behave much like those in total darkness. Such conditions are obtained by growing a plant so that all light which reaches it has passed previously through a solution of potassium bichromate. The blue end of the spectrum is for the most part absorbed, and since these are the rays that affect the movements of growing and mature plant-organs, the plant as far as this kind of light is concerned is in darkness. On the other hand *red and yellow* rays pass unhindered to the plant, and its leaves can continue the manufacture of starch without interference, so that the duration of an experiment may be prolonged without so complete an overthrow of the normal conditions as obtains when the plant is grown in total darkness. Under these conditions the leaves moved upwards in the course of observations extending over six weeks, and remained till the close of the experiments pointing steeply upwards in the highest position which it was mechanically possible to attain. On removing the coloured solution from around the plant a striking thing happened. In the course of two hours all the leaves moved down through an angle of 40° to 60°. The action of pure diffuse light in this case was the greater from the fact probably that the plant had been so long protected from the blue and violet rays.

Finally it must not be supposed that the upward and downward movements of a leaf rachis occur in the same vertical plane. As a matter of fact the leaf points sometimes to right sometimes to left of the positions in which it is at its extreme elevation or depression. Roughly speaking the apex of a leaf axis traces an ellipse in performing one diurnal oscillation, and its extreme *lateral* fluctuation may reach as much as 20° or 25° of arc.

I have dealt in some little detail with these rachis movements, since it is to these that Mr. Nowack attaches so much importance, regarding them as he does as indicating barometric changes several days in advance. I have tried to show that the leaves of *Abrus* exhibit up and down movements not dissimilar in nature to those shown by certain other Leguminous plants: that the most marked of these movements is a diurnal movement, a sinking in the morning, a rising in the evening; and that the regularity of these movements is directly affected by variations in illumination and in temperature. I contend that the explanation of these movements, as also of those of the leaflets, is to be found rather in the action upon the plant of the immediate surrounding influences as light, temperature, and relative humidity combined with individual peculiarities, rather than in far-fetched hypotheses such as those held by Mr. Nowack.

The earthquake and schlagwetter positions of rachis are shown on various plants not infrequently. Six or eight leaves on a single plant may be in one or other of the positions at once. Mr. Nowack no longer regards them as foretelling necessarily either an earthquake or a mine explosion, but sudden changes of barometric pressure at the spots indicated. In the case of the earthquake position, he regards the prophesy fulfilled if after the lapse of a certain number of days after the bending reaches a maximum a sudden change from low to high barometric pressure takes place. Similarly as regards schlagwetter, except that the change is from high to low pressure.

In other words, these positions indicate the sudden development of well-marked high or low pressure centres respectively in the directions

indicated by the leaves and at a distance from the point of observation calculated in a simple manner.

Mr. Nowack usually fixes a period of four or five days some little time ahead of the date on which the curving reached a maximum. This period he speaks of as a "critical period." He is guided in his determination of it partly by data as to great disasters of this kind which he has collected for some years; partly by a consultation of astronomical tables. Mr. Nowack believes in the existence of definite "critical periods," during which catastrophes are prone to occur. This being so, it would carry me into a province quite foreign to the scope of this report were I to follow him into the details of the matter. All that can be done is to compare a list of earthquakes and schlagwetters foretold with the barometric variations which actually occurred at the spots indicated over the "critical periods" in question. This is done in Mr. Scott's report. There will also be found a list of authenticated earthquakes and barographs on the actual day as well as on those preceding and following the date of their occurrence. A perusal of these barographs will show how much colour Mr. Nowack has for his view that earthquakes are necessarily accompanied by suddenly developed anticyclones. Barographs are likewise given for the days on which earthquakes were foretold in October and November. According to the accepted definition of Mr. Nowack's "earthquakes," the prophecy will be sufficiently fulfilled if there is a sudden barometric rise at the times and places in question.

Similarly barographs are given covering the times of the prophesied "schlagwetters." The accepted definition of schlagwetter (for the purposes of this report) is a sudden barometric fall. Examination of the barographs will show how far Mr. Nowack's anticipations have been justified. I am unable to give a list of authentic firedamp explosions for comparison with barometric fluctuations, not from any wish to burke this part of the matter, but because statistics are difficult to procure. Further details will be found in Mr. Scott's report.

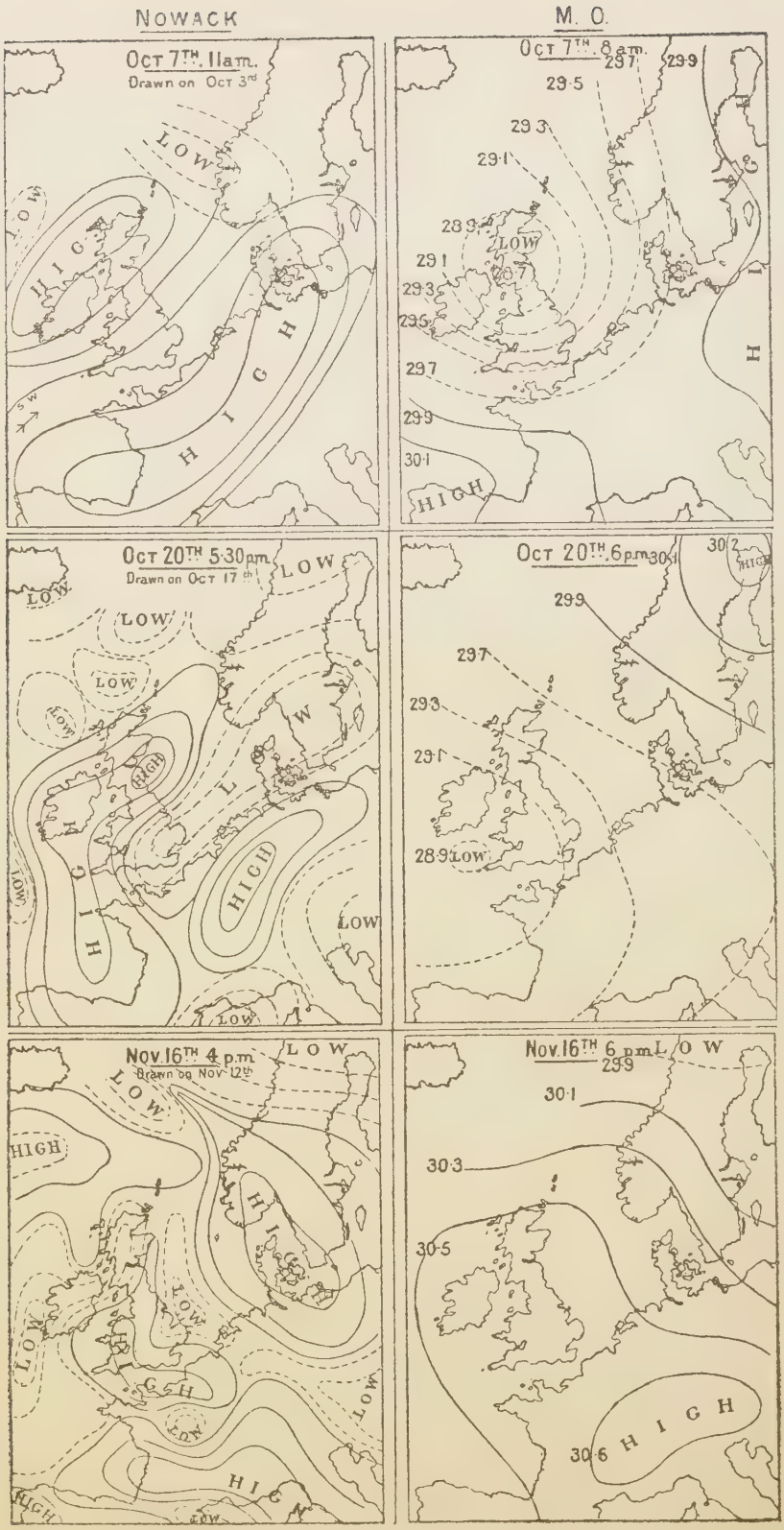
My own view is that these extreme curvatures of the rachis indicate incipient death of the leaf. In no case does the leaf recover after displaying this appearance. The only difference between an earthquake position and a schlagwetter position is, that in the case of the former position the leaf already pointed more or less downwards before the special curvature commenced, whilst in the latter it pointed more or less upwards, and the on-coming curvature does not obliterate this in the basal portion of the rachis.

In conclusion, I contend that all the movements exhibited by the leaves of *Abrus precatorius* depend on causes not so far to seek as those suggested by Mr. Nowack.

The ordinary movements of the leaflets, of rising and falling, are called forth in the main by changes in the intensity of the light. In a humid atmosphere they are more sluggish than in a relatively dry one. In other words when the conditions are favourable for transpiration the movements are most active.

The position for snow and hail is connected intimately, in the cases that have come under my own observation, with a spotting or biting (by insects) of the leaflets, and is not due to any other external factor.

The position for fog and mist and for electricity in the air is probably due to the disturbance caused by varying light, the rhythmical movements of the leaflets being temporarily overthrown.


NOWACK
M. O.
Oct 7TH. 11a.m.
Drawn on Oct 3rd
LOW
HIGH
Oct 7TH. 8 a.m.
29·7
29·9
29·5
29·3
29·1
28·9
LOW
29·1
29·3
29·5
29·7
29·9
30·1
HIGH
Oct 20TH 5·30 p.m.
Drawn on Oct 17th
LOW
HIGH
Oct 20TH. 6 p.m.
30·1
30·2
29·9
29·7
29·3
29·1
28·9 LOW
Nov. 16TH 4 p.m.
Drawn on Nov 12th
LOW
HIGH
Nov. 16TH 6 p.m.
29·9
30·1
30·3
30·5
30·6 HIGH

The position indicating thunder and lightning I take to be pathological from its tendency to recur on the same leaves.

Daily movements of the rachis constitute a periodic function in this as in many other plants with pinnate leaves. The regularity of these oscillations is considerably influenced by both light and temperature.

In conclusion, I have to express my thanks to my assistant, Mr. F. E. Weiss, for his very efficient aid all through the observations above detailed. With his co-operation, Mr. Nowack's weather plants have been continuously under observation for about two months, during part of which time I was away from Kew. On the various points raised in the report his opinion coincides with mine, though in most cases we had come independently to the same opinion.

F. W. Oliver.

Royal Gardens, Kew,
December 1st, 1889.

Dr. Oliver's report needs no comment. It only remained, therefore, to obtain an opinion as to whether there was any agreement between the charts issued by the Meteorological Office, showing each day the actual distribution of barometric pressure, and the charts prepared by Mr. Nowack, which professed to give in advance the same data as obtained from observations of this "Weather Plant." This the secretary of the Meteorological Office, Mr. R. H. Scott, F.R.S., very kindly undertook to give. He has, after an examination of Mr. Nowack's charts, furnished the following report:—

Meteorological Office to Royal Gardens, Kew.

Meteorological Office,
63, Victoria Street, London, S.W,
December 5, 1889.

My dear Dyer,

In answer to your letter of November 12, and the subsequent communications received through Dr. Oliver, I enclose our report on the maps and predictions submitted to me. I forward also drafts of our two plates, and I return all Mr. Nowack's maps. I should like to have one or two of these as samples.

Yours truly,
(Signed) Robert H. Scott.

W. T. Thiselton Dyer, Esq., C.M.G., F.R.S.,
Royal Gardens, Kew.

Report

Of the weather maps, which are drawn by Hr. Nowack some three or four days before the date to which they refer, we have taken three for October 7th and 20th and November 16th respectively, and have endeavoured to reproduce them by the side of copies of our own published maps for the three dates mentioned.

There is no accordance between the successive pairs of maps, as will be seen from the illustration. Plate I.

Earthquakes. We are informed that Hr. Nowack states that earthquakes are associated with the sudden production of an anticyclone locally over the region affected by the shock.

In Symons' Meteorological Magazine for 1884, page 49, will be found a list of all earthquake shocks experienced in these islands of late years, a copy of which is appended. I have compared all of these occurring

between 1869 and 1880 with the published barograms in the Quarterly Weather Report, and have also examined the Kew barogram for April 22nd, 1884, when the well known serious shock occurred in Essex. The results are shown in Plate II., and they afford no confirmation of Hr. Nowack's statement. No barometrical disturbance accompanied any of the shocks. No anticyclone is traceable in the neighbourhood of the region shaken on any of these occasions, except on September 23rd, 1875, when a slight anticyclone (readings 30·1 at centre) prevailed over the north-east of England. The shock, which was described as "a slight local tremor," was felt in north-west England.

In this connexion I enclose an extract from a letter I received many years ago from the late Mr. Robert Mallet, F.R.S., whose authority on seismological matters will be universally recognised.

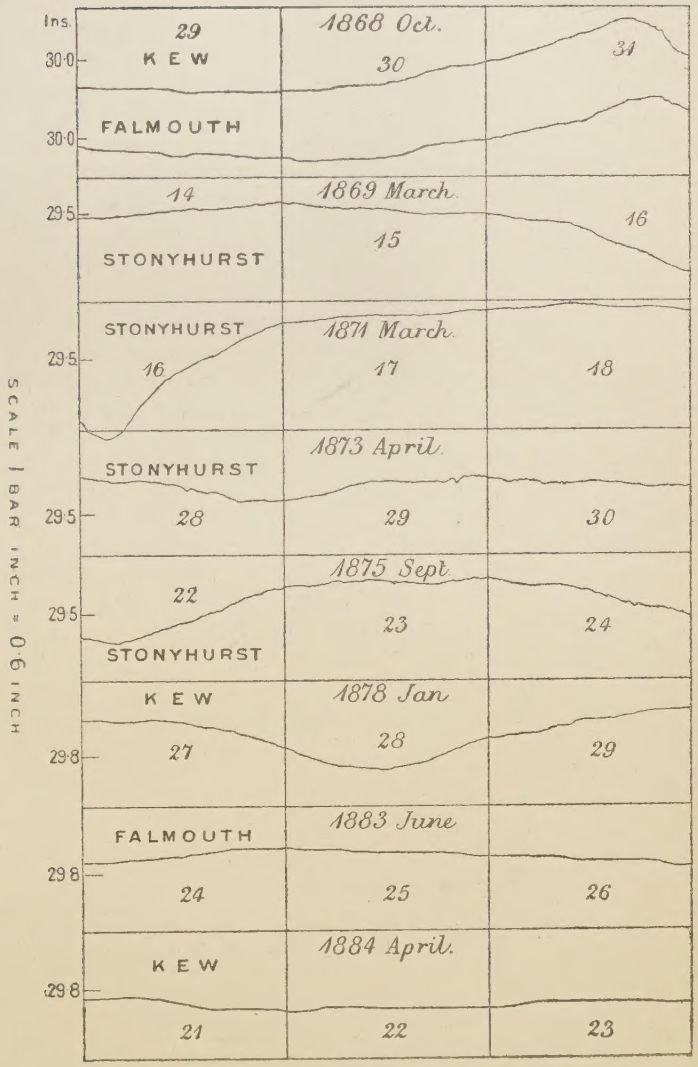
Schlagwetter. It does not appear clear whether Hr. Nowack describes by this term an explosion, or merely the appearance of firedamp.

No materials are available for testing the predictions for the last few months. The reports of H.M. Colliery Inspectors for 1889 will appear next year, and they will contain dates of fatal explosions, but not necessarily those of minor explosions, and certainly no data as to the appearance of firedamp in each mine. On this subject I myself, in conjunction with Mr. W. Galloway, have published three papers, in the Royal Society's Proceedings, Vol. XX., p. 292, and in the Quarterly Journal Meteorological Society, Vol. I., p. 246; Vol. II., p. 195. From these it appears that while there is a decided tendency for firedamp to escape from the coal into the workings when the barometer falls, yet that this action will not explain all the occurrences of foul air, or of explosions. I would refer you to these papers, or to the reports of the Preussische Schlagwetter Commission published in Berlin in 1887.

In conclusion, I have received from Dr. Oliver a list of dates on which I. "Schlagwetter" or "sudden depressions," and II. "Earthquake warnings" or "sudden anticyclones" have been predicted. The comparison of these yields the following results. The order followed is that given in his letter.

I.—*Schlagwetter.*

	Date.	District predicted.	Actual position of nearest Cyclonic Centre on Map.	Result.
1.	October 31 - -	Off Hebrides -	Off Hebrides -	Correct.
2.	„ 29 - -	Near Cork -	Off Hebrides -	Nearly correct.
3.	„ 27 to November 1	Near Newcastle-on-Tyne.	Over British Channel.	Wrong.
4.	„ 14 - -	Near Hanover -	Near Berlin -	Correct.
5.	„ 27 to November 1	Over Luxembourg.	Over British Channel.	Nearly correct.
6.	November 12–18 (probably 14th).	Near Paris -	In Northern Norway.	Wrong.
7.	October 30 - -	Over Central France.	Off Hebrides -	Wrong.
8.	November 12–18 (probably 14th, 17th, or 18th).	Off Cornwall -	In Northern Norway.	Wrong.
9.	November 12–18 (probably 14th, 17th, or 18th).	Over Lancashire	In Northern Norway.	Wrong.


Ins.
30·0
30·0
29·5
29·5
29·5
29·8
29·8
29·8
KEW
29
30
31
FALMOUTH
1868 Oct.
STONYHURST
14
15
16
1869 March.
STONYHURST
16
17
18
1871 March.
STONYHURST
28
29
30
1873 April.
22
23
24
1875 Sept.
STONYHURST
KEW
27
28
29
1878 Jan
FALMOUTH
24
25
26
1883 June
KEW
21
22
23
1884 April.
SCALE 1 BAR INCH = 06 INCH

On the morning of October 16th, when colliery explosions occurred in Staffordshire, no barometrical disturbance was noted.

II.—*Earthquake Warnings.*

	Date.	District predicted.	Region occupied by nearest Anticyclone.	Result.
1.	October 29 - -	Near Vienna -	Southern Russia	Wrong.
2.	„ 26 - -	Near Bordeaux	Scandinavia -	Wrong.
3.	„ 14 (about) -	Near Corunna -	Spain - -	Correct.
4.	November 12–18 (probably 14th, 17th, and 18th).	Off Scilly Isles -	Over Central Europe, moving northwards.	Wrong.
5.	November 12–18 (probably 14th, 17th, and 18th).	Off Ushant -	Over Central Europe, moving northwards.	Wrong.
6.	October 27 to November 1	Near Brest -	Over Russia -	Wrong.
7.	November 12-18 - -	South-west England.	Central Europe, moving northwards.	Wrong.
8.	October 29 (Oct. 27 to Nov. 1).	Northumberland	Southern Russia, South of Spain (Nov. 1).	Wrong.
9.	October 29 - -	North-west Ireland.	Southern Russia	Wrong.

It will be seen that of the "Schlagwetter" two of the cyclones were predicted correctly, and two nearly so, while there were five total failures. In not a single instance did these appear suddenly. Of the anticyclones there was one correctly predicted and eight failures.

ROBERT H. SCOTT.

Meteorological Office,
December 5th, 1889.

LIST OF EARTHQUAKE SHOCKS IN ENGLAND.

Date.	Locality of Earthquake Shock.
1866. September 13 - -	Devonshire (Sidmouth).
1867. February 23 - -	Westmoreland (Ambleside).
1868. January 4 -	Somersetshire (Wellington).
1868. October 30 - -	Monmouthshire.
1869. March 15 - -	South Lancashire and Yorkshire.
1871. March 17 - -	North Lancashire.
? 1873. April 29 - -	Doncaster.
1875. September 23 - -	North-west Yorkshire.
1878. January 28 - -	France and the south-east of England.
1883. June 25 - -	Devon and Cornwall.
1884. April 22 - -	Eastern, Midland, and South-eastern parts of England.

[Enclosure.]

Offices, 7 Westminster Chambers,
Victoria Street, London, S.W.,
July 15th, 1870.

"You are quite right in saying that there is no establishable connexion between *any* of the phenomena of meteorology, *i.e.*, anything in or affecting the atmosphere and earthquakes, unless of a cyclical nature. Then, it is not only possible but probable that there may be, *e.g.*, that long and unusual periods of rain or of drought in volcanic countries may affect the tendency to eruption, and so indirectly that to earthquake.

(Signed) Robert Mallett.